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January 6, 1994

By Hand

RECEIVED

FEDERAL COMM COMMISSION
OFFICE OF THE SECRETARY

Mr. William F. Caton
Acting Secretary
Federal Communications Commission
1919 M Street, NW
Washington, DC 20554

Re: Ex Parte Presentation
CC Docket No. 92-297
Local Multipoint Distribution Service

Dear Mr. Caton:

On behalf of Suite 12 Group ("Suite 12"), petitioner in the above-referenced rulemaking proceeding, enclosed please find two (2) copies of a technical study prepared by Roger L. Freeman, Roger Freeman and Associates, and Suite 12 engineer-inventor Bernard B. Bossard, entitled "<u>The LMDS System Does Not Interfere With NASA ACTS Satellites — Supplemental Rebuttal</u>," which confirms that the Local Multipoint Distribution Service ("LMDS") does not interfere with the NASA ACTS satellite system ("ACTS").

Please place these two copies of this technical study in the above-referenced docket. Any questions regarding this study should be directed to the undersigned.

Sincerely,

Michael R. Gardner

Michael R. Gardner
Charles R. Milkis
William J. Gildea III
Counsel for Suite 12 Group

Enclosures

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January 6, 1994

By Hand

Dear Chairman Hundt
Commissioner Quello
Commissioner Barrett
Commissioner Duggan

Re: CC Docket No. 92-297
Local Multipoint Distribution Service
"The LMDS System Does Not Interfere With NASA ACTS Satellites — Supplemental Rebuttal"

In response to NASA's latest assertions that the Local Multipoint Distribution Service ("LMDS") may interfere with NASA's ACTS satellite system, Suite 12 Group ("Suite 12"), today filed the enclosed technical study entitled "The LMDS System Does Not Interfere With NASA ACTS Satellites — Supplemental Rebuttal," which unequivocally confirms that LMDS does not interfere with the ACTS system ("ACTS").

Specifically, this study confirms that the Interference to Noise ratio ("I/N") of an LMDS signal into an ACTS satellite receiver will be approximately 33.5 dB to 46.4 dB below noise, which is generally 23 dB better than NASA itself has specified is required. This supplemental rebuttal to NASA's interference claim was jointly prepared by Roger L. Freeman, Roger Freeman Associates and Suite 12 inventor-engineer Bernard B. Bossard.

In view of the conclusions contained in this technical study and the other documents and studies recently placed into the record by Suite 12, and in view of the Commission's own findings expressed in its NPRM released early in 1993, the record in this proceeding overwhelmingly supports the Commission's previously proposed reallocation of the largely unused 28 GHz band for the pro-competitive LMDS, with the issuance of two 1 GHz licenses per service area.

Please direct any questions regarding this matter to the undersigned.

Sincerely,

Michael R. Gardner

Michael R. Gardner
Counsel for Suite 12 Group

Enclosure
cc Acting Secretary William F. Caton (for inclusion in the LMDS rulemaking record)

The LMDS System Does Not Interfere with NASA ACTS Satellites -- Supplemental Rebuttal

by

• ***Bernard B. Bossard*** •
Suite 12 Inventor-Engineer

• ***Roger L. Freeman*** •
Roger Freeman Associates

THE LMDS SYSTEM DOES NOT INTERFERE WITH NASA ACTS SATELLITES – SUPPLEMENTAL REBUTTAL

1. Statement and Objective

NASA, on page 21 of its March 16, 1993 Comments submitted to the FCC in the LMDS rulemaking proceeding, states: "Depending upon the assumptions made, interference from the LMDS systems would enter various geostationary FSS satellite receivers 2 to 14 dB below the receiver thermal noise level based on conservative assumptions.....An appropriate criteria for interference would appear to be a level 10 dB below the thermal noise. Thus, there is a potential for a fully developed LMDS to cause unacceptable interference to a fixed satellite..."

On November 24, 1993, Suite 12 Group submitted a technical study which confirmed that LMDS does not interfere with the NASA ACTS satellite system. Subsequently, Suite 12 has supplemented its interference calculations, with the input of additional technical consultants, and the use of additional reference data. This further analysis, as set forth below, again completely refutes NASA's interference claim by using standard link budget analysis as described in numerous textbooks, which result in an LMDS interference level of 33.5 dB to 46.4 dB below satellite receiver noise, or generally 23 dB better than NASA itself requires.

2. NASA Supporting Argument

NASA's supporting argument is found in paragraph 4.3.1 Interference to Geostationary FSS Uplinks in document "Appendix B - Sharing between Local Multipoint Distribution Service and Other Services in the 27.5-29.5 GHz Band."

Several statements made by NASA in this paragraph are in **error**. These statements are as follows:

1. LMDS transmitters uniformly occupy CONUS, 3,500,000 square miles.
2. 20 square mile cell area per LMDS transmitter.
3. 0 dBi gain for LMDS transmitters in the direction of the ACTS satellite.

The following NASA points we assume to be correct:

1. The power density of the LMDS signals is taken to be -77.55 dBW/Hz
2. Elevation angle of ACTS is 30 degrees.

Their first point is unreasonable and the 3.5 million square mile figure is exaggerated. The total land area of the 50 United States is indeed 3.5 million square miles, including Alaska and Hawaii. But CONUS is defined as the contiguous or conterminous United States (i.e., "the lower 48") which has a land area of about 3 million square miles (Larousse Encyclopedia of the World, Hamlyn, NY 1964). About one third of this landmass is uninhabitable. About half of the habitable portion has very low population densities, not amenable to viable LMDS operation. One source of information dealing with this subject is the Department of Commerce, Bureau of the Census "Commerce News" of December 18, 1991 Table 1 where 75% of the U.S. population lives on 2.5% of the land. (See Appendix 3.) Using population and land mass data from "1994 Commercial Atlas & Marketing Guide," 125 edition, Rand McNally, it is derived that more than 90% of the population lives on 10% of the land area. This latter data alone incurs a 10 dB error in the NASA documentation for it assumes that LMDS cells will be uniformly distributed across the entire CONUS land mass.

The second point is also somewhat exaggerated. While NASA assumes that a typical LMDS model cell has a 20 square mile area, in actual fact, a cell in New

York has a 3-mile radius and 28.3 square-mile area. NASA also assumes the same cell area throughout the nation, whereas in actual fact the average for the nation is a cell with a 4.1-mile radius and an area of 52 square miles. (See Appendix 2 which indicates the various rainfall geographic regions in the U.S. with the accompanying attenuation and cell size.)

The third point contains yet another error in NASA's argument. Figure 1 shows a model of a typical LMDS transmitting antenna, designed, fabricated and tested by Andrew Corporation. Figure 1 shows the antenna's vertical pattern. To show the pattern of the antenna, one must turn the antenna, lifting from the left so that the main beam faces right. With this configuration, at a 30-degree elevation angle the relative power is -27.1 dB. The boresight antenna gain is +12.1 dBi and the gain at 30 degrees is -15.0 dBi (+12.1 dBi -27.1 dBi). NASA claims 0 dBi at this point or an error of 15 dB in their calculations.

3. Calculation of LMDS Isotropic Receive Level in ACTS Spot Beam Antenna

The LMDS interference level into the ACTS 53 dBi antenna transponder is calculated by the link budget method.[1] At a 30-degree elevation angle, the range to the geostationary ACTS satellite is a maximum of 23,994 statute miles. This value was calculated based on Reference 1, the COMSAT nomogram, for range and elevation angle. Conversion from nautical miles to statute miles was based on 6,076.1 feet, the corrected value for the nautical mile (rather than the older 6,080 feet). (Reference 2.) It is important to note that the elevation angles for various spot

---

[1] See "Satellite Communication Systems Engineering," Prichard, Sciulli (Prentice Halla); "Satellite Communications, " Elbert (Artech House); "Communications Satellite Handbook," Morgan & Gordon (John Wiley & Sons); "Satellite Telecommunications and Broadcasting," Kontor (Artech House); "Radio System Design for Telecommunications," Freeman (John Wiley & Sons).

beam cities vary from 31 to 53 degrees and the antenna gain varies from 46.1 dB to 53.0 dB. For the purpose of the following analysis we allowed the 0.33° beamwidth to exist even though NASA agrees it will be less than that for various cities, hence our analysis results in larger average areas than NASA anticipates.

The resulting free space loss (FSL) at 28 GHz is calculated as follows:

$$\begin{aligned} FSL &= 36.58 + 20\text{Log}28{,}000 + 20\text{Log}23{,}994 \\ &= 213.12 \text{ dB} \end{aligned}$$

Link budgets are carried out using power spectral density (PSD) values and NASA parameters when those parameters are deemed correct.

Parameter	**Value**	
LMDS transmitter output	+20.0 dBW	
TWT backoff	-7.0 dB	
Power for 49 TV chs	+13.0 dBW	(1000 MHz)
Power spectral density	-77.0 dBW/Hz	(which is the sum of +20 dBW - 7.0 dB - 90 dB) (90 dB is the conversion of 1000 MHz to Hz)
Line losses	-1.0 dB	
Antenna gain	-15.0 dBi	(at 30° elev. angle)
EIRP	-93.0 dBW/Hz	[sum of -77 dBW/Hz -1 dB -15 dBi]
Free space loss	-213.12 dB	
Polarization isolation	-3.0 dB	
Atmos. absorp. loss	-0.5 dB	
Isotropic receive level	-309.62 dBW/Hz	[sum of -93 dBW/Hz -213.12 dB -3.0 dB -0.5.dB]

ACTS Receive Signal Level, One LMDS Transmitter

From Table 4.3-1, page B-13 of referenced NASA document, we examine two ACTS/ACTS-like receiving systems.

1. ACTS max. spot beam antenna gain 53.00 dBi, Tr = 920 K (noise temp. of receiver)

   Isotropic rec. level (1 LMDS) = -309.62 dBW/Hz (see above table)

Transmission line loss	-1.0 dB
<u>Antenna gain</u>	<u>+53.0 dBi</u>
Receive signal level ("RSL")	+257.62 dBW/Hz

2. ACTS-like, gain +27.0 dBi (CONUS coverage), Tr = 800 K (noise temp. of receiver)

Isotropic receive level (1 LMDS)	-309.62 dBW/Hz (see above table)
Transmission line loss	-1.0 dB
<u>Antenna gain</u>	<u>+27.0 dBi</u>
RSL	-283.62 dBW/Hz

NASA Aggregates of LMDS Transmitters at 30-Degree Elevation Angle

From Table 4.3.1-1 of NASA referenced document, the following aggregates of LMDS transmitters have been calculated. The 3-dB G/T footprints have been recalculated, and we use a very conservative population density factor correction of -5 dB for the 53 dB spot beam, and -10 dB for the 27 dB CONUS coverage beam based on our Bureau of Census reference. For spot beam coverage in New York, the average cell size is 28.3 square miles, and for CONUS coverage, the average cell size is 52 square miles.

1. 53 dBi antenna, 28,000 sq. miles. Divide by 28.3 square miles per cell. (See Appendix 2 (New York Area and D-2 area only))
   Total cells: 990 cells (i.e., 990 LMDS transmitters).
   Additive dBs to receive signal level: 30 dB

2. 27 dBi antenna, CONUS coverage (3,000,000 sq. miles), divided by 52 square miles.
   52 square miles.
   Total cells: 57,692 cells
   Additive dBs to receive signal level: 47.61 dB

Interference Analysis

In each case we calculate the receive signal level by adding the aggregate value in dB to the single LMDS receive signal level value.

Case 1: 53 dBi maximum gain spot beam antenna, 990 cells (LMDS transmitters). Additive dBs to RSL: 30 dB. Population density correction factor of -5 dB.

RSL (1 LMDS)	-257.62 dBW/Hz
990 LMDS	+30.0 dB
population density correction factor	-5.0 dB
I_o	-232.62 dBW/Hz
N_o	-199.0 dBW/Hz (rec. noise temp=920 K)
I_o/N_o	-33.62 dB

Case 2: 27 dBi antenna (CONUS coverage), 57,692 cells (LMDS transmitters), additive dBs to RSL: 47.61 dB. Population density correction factor 10 dB. (See Appendix 3).

RSL (1 LMDS)	-283.62 dBW/Hz (see page 3)
57,692 LMDS	+47.61 dB

population density correction factor	-10.0 dB
I_0	-246.01 dBW/Hz
N_0	-199.57 dBW/Hz (rec. noise temp = 800 K)
I_0/N_0	-46.44 dB

Actual Interference Analysis: ACTS for Four Major Spot Beam Cities

Uplink aggregate LMDS interference levels and I_0/N_0 values are calculated for four major U.S. cities using the high-gain ACTS receiving antenna with 53 dBi boresight gain as follows:

Table 1. Interference Analysis - Input Data

CITY	LAT. DEG.	LONG. DEG.	RANGE (MI)	ELEV. ANGLE (DEG.)	COVERAGE[1] MI²	SAT. ANT. GAIN[2]	CELL SIZE[3] MI²
New York	40	74	23,652	35.9	23,000	53 dB	28.3
Los Angeles	34	118	23,205	45.8	18,300	49.2 dB	109
Miami	25	80	22,920	52.6	15,700	50.6 dB	9.0
Seattle	48	123	23,970	31.2	28,000	49.1 dB	82

Footnotes to Table 1:

[1] Based on 0.33° beamwidth; actual beamwidth at edge of coverage is 0.27° resulting in even smaller coverage areas (See Appendix 1).

[2] See Appendix 1.

[3] See Appendix 2.

Legend for Table 1:

Col. 1	**CITY**: Principal operational locations for ACTS.
Col. 2/3	**LATITUDE AND LONGITUDE**: Latitude and longitude of cities.
Col. 4	**RANGE**: Range to ACTS based on elevation angle shown in Column 5.
Col. 6	**COVERAGE**: ACTS G/T contour area based on our calculations.
Col. 7	**SAT. ANTENNA GAIN**: ACTS antenna gain based on 100° West longitude ACTS subsatellite point.
Col. 8	**CELL SIZE**: LMDS cell area for each city. Cell radius is governed by excess attenuation due to rainfall with a 99.9% time availability.

NEW YORK

Parameter	Value	
EIRP (1 LMDS) in PSD	-93.0 dBW/Hz	
Free Space Loss	-213.3 dB	
Polarization isolation	-3.0 dB	
Gaseous absorption loss	-0.5 dB	
Isotropic receive level	-309.8 dBW/Hz	
ACTS antenna gain	+53.0 dBi	(estimate)
Transmission line loss	-1.0 dB	
I_o (for one LMDS)	-257.8 dBW/Hz	

New York coverage is 23,000 square miles, an LMDS cell occupies 28.3 square miles. Total LMDS cells for New York spot beam is 23,000/28.3 = 813 cells. This equates to 29.1 dB to be added to I_o value above. Based on our Bureau of the Census reference, we use a -5 dB population density correction factor.

$$I_o = -257.8 \text{ dBW/Hz} + 29.1 \text{ dB} - 5 \text{ dB}$$
$$= -233.7 \text{ dBW/Hz}$$
$$N_o = -199.0 \text{ dBW/Hz}$$
$$I_o/N_o = -34.7 \text{ dB}$$

LOS ANGELES

Parameter	Value
EIRP (1 LMDS) in PSD	-93.0 dBW/Hz
Free Space Loss	-213.14 dB
Polarization isolation	-3.0 dB
Gaseous absorption loss	-0.5 dB
Isotropic receive level	-309.64 dBW/Hz
ACTS antenna gain	+49.2 dBi
Transmission line loss	-1.0 dB
I_o (for one LMDS)	-261.44 dBW/Hz

Los Angeles has a spot beam coverage of 18,300 square miles. Total LMDS cells, based on 109 square miles per cell, is 168 cells (i.e., 168 LMDS transmitters). Thus, 22.25 dB is added to the I_o value above. A population density correction factor of -5 dB is used based on our Bureau of the Census reference.

$$I_o = -261.44 \text{ dBW/Hz} + 22.25 \text{ dB} - 5 \text{ dB}$$
$$= -244.19 \text{ dBW/Hz}$$
$$N_o = -199.0 \text{ dBW/Hz}$$
$$I_o/N_o = -45.19 \text{ dB}$$

MIAMI

Parameter	Value
EIRP (1 LMDS) in PSD	-93.0 dBW/Hz
Free Space Loss	-213.03 dB
Polarization isolation	-3.0 dB
Gaseous absorption loss	-0.5 dB
Isotropic receive level	-309.53 dBW/Hz

ACTS antenna gain	+50.6 dBi
Transmission line loss	-1.0 dB
I_o (for one LMDS)	-259.93 dBW/Hz

Miami has a spot beam coverage area of 15,700 square miles. Cell area is 9 square miles. Total cells is 1,744, thus 32.42 dB must be added to the I_o value above. A population density correction factor of -5 dB is also used as above.

$$I_o = -259.93 \text{ dBW/Hz} + 32.42 \text{ dB} - 5 \text{ dB}$$
$$= -232.51 \text{ dBW/Hz}$$
$$N_o = -199.0 \text{ dBW/Hz}$$
$$I_o/N_o = -33.51 \text{ dB}$$

SEATTLE

Parameter	**Value**
EIRP (1 LMDS) in PSD	-93.0 dBW/Hz
Free Space Loss	-213.42 dB
Polarization isolation	-3.0 dB
Gaseous absorption loss	-0.5 dB
Isotropic receive level	-309.92 dBW/Hz
ACTS antenna gain	+49.1 dBi
Transmission line loss	-1.0 dB
I_o	-261.82 dBW/Hz

Seattle has an ACTS spot beam coverage area of 28,000 square miles. Based on an LMDS cell area of 82 square miles, there will be 341 cells (LMDS transmitters) in the area. Thus, the I_o value above must be increased about 25.33 dB. Again we use a population density correction factor of -5 dB.

$$I_o = -261.82 \text{ dBW} + 25.33 \text{ dB} - 5 \text{ dB}$$
$$= -241.49 \text{ dBW/Hz}$$
$$N_o = -199.0 \text{ dBW/Hz}$$
$$I_o/N_o = -42.49 \text{ dB}$$

Notes:

The analyses above include polarization coupling isolation loss of 3 dB. If the ACTS receiving antenna is linearly polarized, only half of the LMDS emitters are on one polarization. If the antenna is circularly polarized, there is a 3 dB polarization coupling loss between linear and circular.

The ACTS G/T footprint is defined by a 3 dB contour. In other words, LMDS transmitters located right on the contour would have levels into the ACTS receiver 3 dB below that calculated. Other LMDS transmitters would be 2 dB down and still others 1 dB down. Only a few LMDS transmitters would have the level stated in the link budget.

4. Conclusions

In each case we have shown that the I_o/N_o values we have calculated well exceed the NASA requirement of an I_o/N_o of at least -10 dB. It proves that even aggregates of large numbers of LMDS transmitters combining in space do not interfere with ACTS uplinks on elevation angles as low as 30°.

The NASA study of LMDS interference is fraught with errors. The total of NASA's errors equal 34 dB for CONUS (NASA calculates I_o/N_o of -12.5 dB while actual calculations are an I_o/N_o of -46.4 dB). For the spot beam coverage, the best case error is 32 dB (NASA's I_o/N_o is -1.7 dB while actual Miami calculations are an I_o/N_o of -33.5 dB). These miscalculations attempt to lead the Commission to incorrect conclusions.

REFERENCES

1. "Determination of Range, Azimuth and Elevation Angles," A single-sheet nomogram prepared by COMSAT, L'Enfant Plaza, Washington, DC 1968.

2. Roger L. Freeman, "Reference Manual for Telecommunication Engineering," 2nd ed., John Wiley & Sons, NY 1993. Section 30.

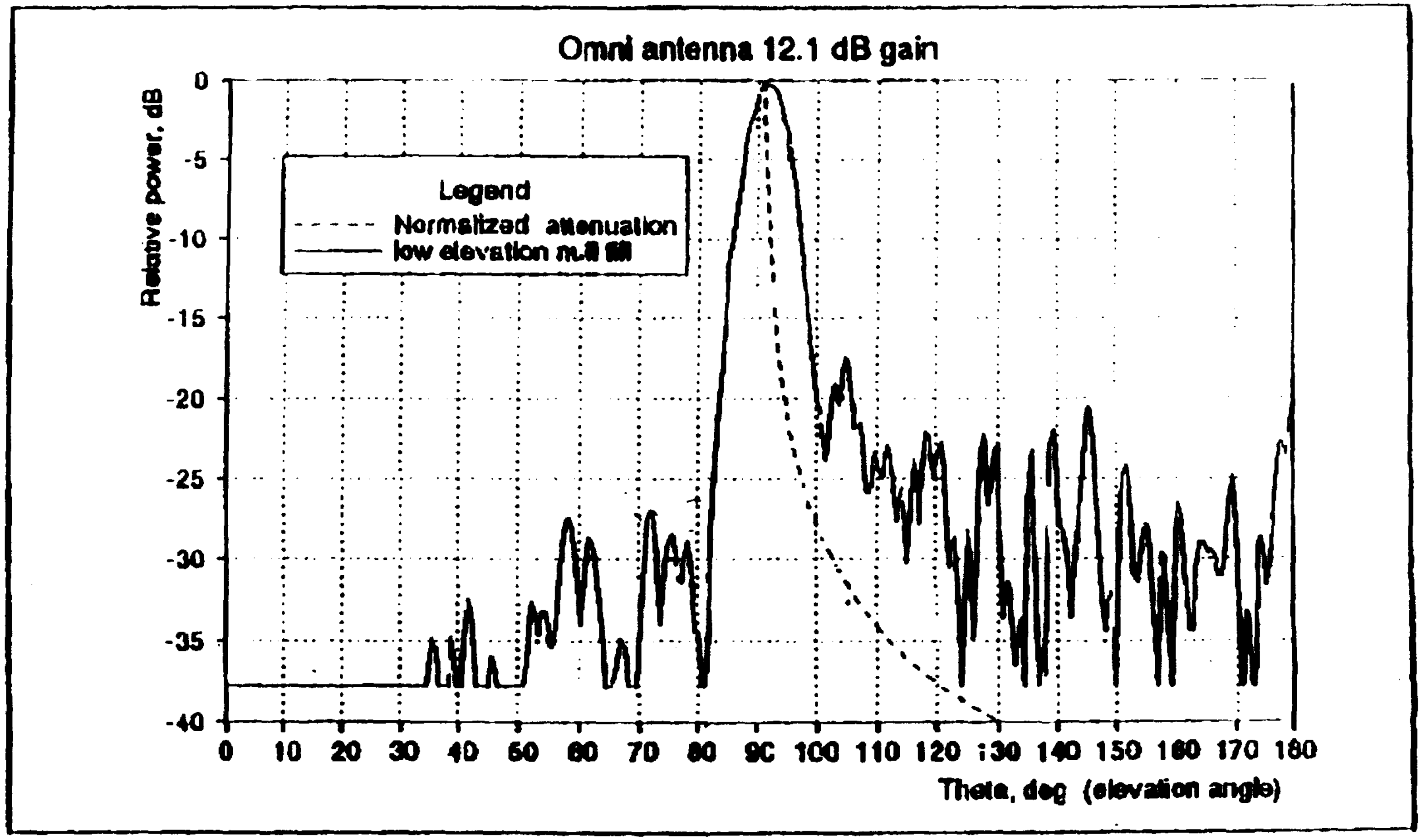


Figure 1

LMDS transmitting antenna radiation diagram as measured on Andrew Corporation prototype.

System Antenna Coverage

ACTS

The ACTS multibeam antenna system provides electronically controlled high-gain spot beams and is a key technology to be validated as part of the ACTS flight system. The multibeam antenna system consists of separate transmitting and receiving offset Cassegrain antennas, each with a dual, gridded subreflector in a piggyback configuration. The 30-GHz receiving antenna is 2.2 m in diameter; the 20-GHz transmitting antenna is 3.3 m in diameter. The antenna diameters are scaled so that the gains and spot beam sizes are the same for both uplink and downlink beams. The expected nominal ranges of gain-to-noise-temperature ratio and effective isotropic radiated power are given in table I. The transmitting antenna's main reflector is equipped with a two-axis drive that allows vernier

TABLE I.—SUMMARY OF ACTS LINK BUDGET
[Values subject to change as design is stabilized.]

Beam	Receiving polarization[a]	Receiving	Transmitting	Spacecraft effective isotropic radiated power, dB	Spacecraft gain-to-noise-temperature ratio, dB/K
		Gain (at edge of coverage[b]), dB			
East family					
East scan sector	Horizontal	[c]47.7	[c]46.8	59.6	17.0
Houston	↓	50.8	50.6	62.9	19.2
Kansas City		50.8	50.7	63.0	19.4
Los Angeles–San Diego		49.2	48.1	60.4	17.1
Miami		50.6	50.2	62.6	18.9
Nashville–Huntsville		50.9	50.8	63.0	20.0
Seattle–Portland		49.1	48.3	60.6	17.8
West family					
West scan sector	Vertical	[c]46.1	[c]47.1	59.4	16.0
Dallas	↓	49.2	50.6	62.6	18.0
Denver		48.9	50.2	62.3	17.7
Memphis		49.5	50.9	63.0	18.1
New Orleans		49.3	50.8	63.0	18.1
Phoenix		48.5	48.8	61.0	17.5
San Francisco		48.1	46.1	57.9	16.8
White Sands		48.9	49.6	62.1	17.7
Steerable		----	----	55.6	----
Stationary beams					
Cleveland	Horizontal	50.5	51.3	[d]57.8/64.0	20.1
Atlanta	Vertical	50.8	51.4	[d]57.8/64.0	19.5
Tampa	Vertical	50.0	51.0	[d]57.4/63.7	19.8

[a] Transmitting polarization is orthogonal to receiving polarization.

[b] Edge of coverage for spot beams is defined as 0.27° beamwidth and is nominally 3 dB less than peak gain.

[c] Minimum scan sector gain.

[d] Ratio of low-power to high-power modes.

adjustments of the boresight to align it with the receiving antenna. The front subreflector is gridded to pass one sense of polarization and reflect the orthogonal polarization. The back subreflector is solid and reflects the polarization transmitted by the front subreflector. The focal axes of the two subreflectors are tilted with respect to the main reflector's plane of symmetry so that the two orthogonally polarized feed assemblies (east family and west family) can be placed side by side without mechanical interference. Compact, conical, multiflare horns formed by three flared waveguide sections are used for the fixed and isolated spot horns. To meet the stringent spacecraft pointing requirements (0.025°), the receiving antenna will have a monopulse tracking capability associated with the Cleveland fixed beam.

ACTS will employ two hopping spot beam families and three fixed beams for both transmitted and received signals (fig. 3). The beams will provide the coverage shown in figure 8. The hopping beams will be programmed to visit only those areas with traffic for any given experiment scenario. The hopping beams, designed primarily for the baseband processor operating mode, consist of two independent uplink and downlink beams (four beams total) providing simultaneous coverage at the same frequency. The half-power beamwidth of these spot beams is approximately 0.33°, covering roughly a 135-mile diameter. One uplink-downlink beam combination covers the east hopping beam family and the other covers the west hopping beam family. The east family consists of (1) an east scan sector—contiguous areas in the eastern portion of the United States and (2) six isolated spots covering Miami, Nashville–Huntsville, Houston, Kansas City, Seattle–Portland, and Los Angeles–San Diego. The west family

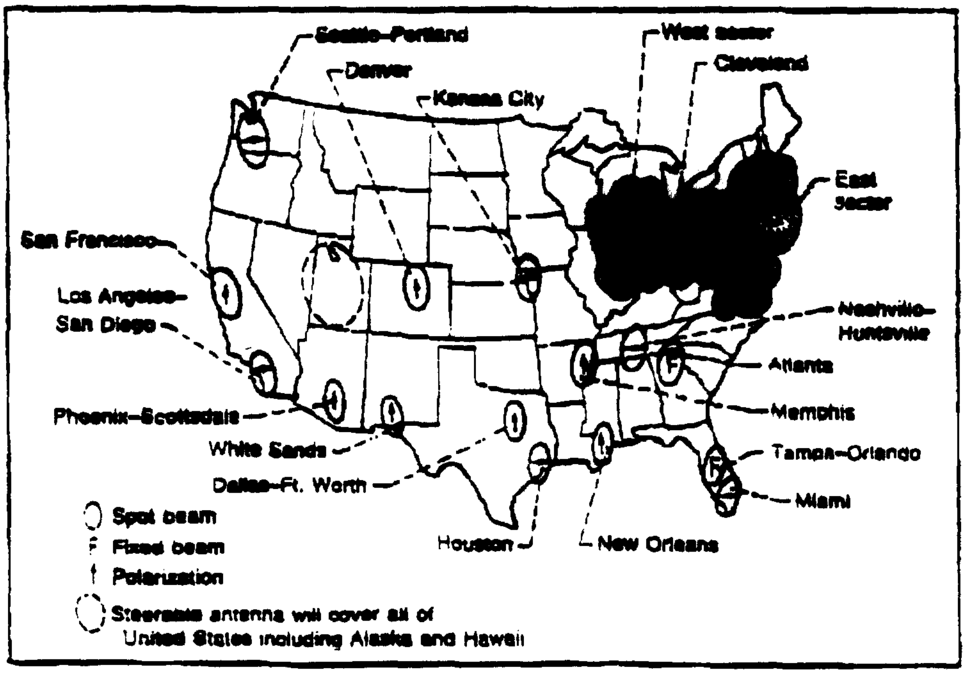


Figure 8.—ACTS multibeam antenna coverage. (ACTS at 100° west longitude.)

ACTS Parameters

Frequency Bands

Uplink 29.0 - 29.9 GHz
Downlink 19.2 - 20.1 GHz
Downlink Beacons at 27.505, 20.185, and 20.196 GHz
Uplink Beacon at 29.975 GHz

Antenna size

Low burst rate terminals LBR-2: 1.2 m and 2.4 m
NASA Ground Station NGS in Cleveland: 5 m
High burst rate terminals HBR: 4 - 5 m

Transmission Rates and Bandwidth

LBR-1:
Uplink 110.592 Msps with no coding (55.29 Msps with rate 1/2 coding)
165.88 MHz carrier Bandwidth, center frequency at 29.236 GHz
Downlink 110.592 Msps
165.88 MHz bandwidth, center frequency at 19.44 GHz

LBR-2:
Uplink 27.648 Msps with no coding (13.3 Msps with rate 1/2 coding)
41.472 MHz carrier bandwidth, center frequencies at 29.291 and 29.236 GHz
Downlink 110.592 Msps
165.88 MHz bandwidth, center frequency at 19.44 GHz

HBR:
Uplink 500 Msps, 750.0 MHz carrier Bandwidth, center frequency at 29.420 GHz
221.18 Msps, 331.77 MHz Bandwidth, center frequencies at 29.160 and 29.680 GHz
Downlink 500 Msps, 750.0 MHz carrier Bandwidth, center frequency at 19.70 GHz
221.18 Msps, 331.77 MHz Bandwidth, center frequencies at 19.440 and 19.960 GHz

EIRP

LBR-2 1.2 m: ~ 60 dBW
LBR-2 2.4 m: ~66 dBW
HBR: ~75 dBW

Elevation Angles

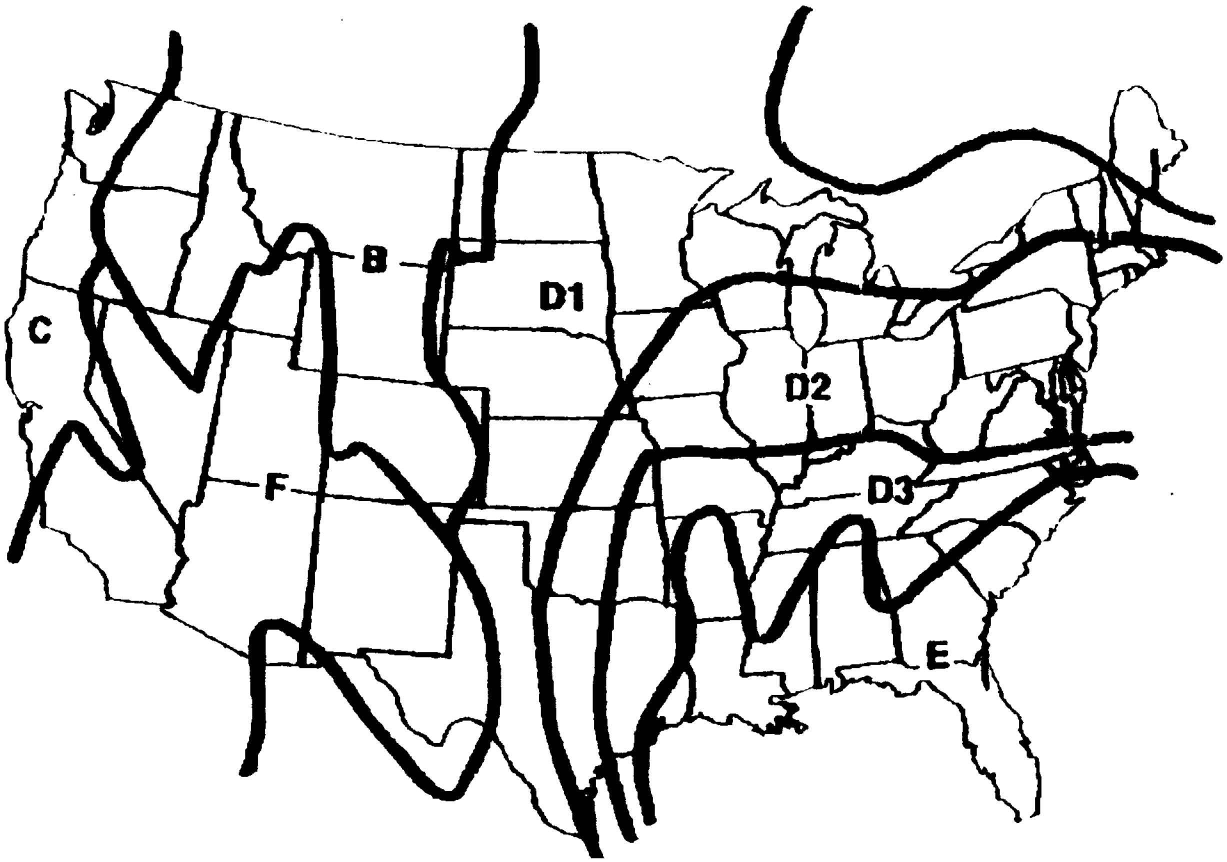
Satellite @ 100 deg West

New York: 35.9 deg.
Seattle: 31.2 deg.
Los Angeles: 45.8 deg.
Miami: 52.6 deg.

Coverage & Satellite EIRP

See attached.

GEOGRAPHIC REGIONS OF SIMILARITY IN RAINFALL STATISTICS
(From Crane and CCIR)



Region	mm/hr	Attenuation/mile	Area sq.mi.
F	5.5	1.5 dB	109
B	6.8	1.8 dB	92
C	7.2	2.0 dB	82
D1	11	3.2 dB	48
D2	15	4.6 dB	30
D3	22	6.7 dB	20
E	35	11.00 dB	9

RAND McNALLY

1994 COMMERCIAL ATLAS & MARKETING GUIDE

125th Edition

Printed and Published by

Rand McNally

Ranally Metro Areas: Population Data

The Ranally Metropolitan Areas (RMAs) listed in this table represent Rand McNally's definitions of the metropolitan areas of the nation's major cities. They are designed to provide accurate information on the population change and areal extent of each metropolitan area. The RMAs are defined on a sub-county basis; this is in contrast with the U.S. government's Metropolitan Statistical Areas (MSAs), which are generally defined in terms of whole counties. Because the RMAs are based on these smaller areas, the RMAs that approximate MSAs comprise about 92% of the MSA population although only about 28% of the MSA area.

The RMAs have been defined for all areas with an estimated population of at least 50,000 and for selected areas of less than 50,000. There are now 452 RMAs, 415 of which have populations of 50,000 or more. The other 37 are defined as RMAs because their populations are close to 50,000, because they include a central city of an official MSA, or because they are of special significance to the state in which they are located. A more detailed description of the criteria used for defining RMAs is on page 97. The map on pages 122–123 shows the location of all RMAs and the individual state maps, pages 138–245, depict the areal extent of individual RMAs.

The table contains 1992 population estimates for each RMA, its central city (or cities), and suburbs. All RMAs with a population over 50,000 are ranked. In addition the table presents the 1990 population for RMAs; a 1990–1992 percent of population change for RMAs, central cities, and suburbs; and the land area of RMAs and central cities.

Following this table are summaries of the RMA population by region and by state, and a list of RMAs by size in descending order. Two tables on page 134 list the RMAs that are most rapidly growing, and most rapidly losing in population.

The tables on page 126 indicate several population trends that are currently underway in the nation. Many larger metropolitan areas, especially those in the Northeast and the Midwest, have experienced little growth since 1970. During the 1970s, the RMAs as a group increased by only 9.1% compared with 11.4% for the nation as a whole and 17.7% for nonmetropolitan territory. Growth in the 1980s reversed this trend and by 1990 RMAs had increased by 10.7%, the whole nation by 9.8% and non-metropolitan areas by the least, 7.3%.

The RMAs in the South and West have continued the rapid growth they exhibited during the 1980s, showing a 1990–1992 increase of 4.6% and 5.9% respectively. Midwest RMAs grew more rapidly than in the 1980s (2.3%) while the Northeast shows the least growth (1.0%).

Suburbs continued to grow faster than central cities in all regions. The central cities of the Midwest and the Northeast have gained population since 1990, 1.6% and .4%, respectively. Central cities in the South and West grew more rapidly, 4.1% and 5.8%.

All population data in the table are rounded to the nearest hundred, and all area data to the nearest square mile. Percent changes are computed on the rounded data.

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South (excl. DE, MD, DC, and WV)

Dallas-Ft. Worth, TX . . .	3,841,100	3,608,600	6.5	1,534,400	5.5	2,308,700	7.2	2,842	623	623
Miami-Ft. Lauderdale, FL	3,511,900	3,456,600	4.5	526,700	3.7	3,085,200	4.6	1,073	67	67
Houston, TX	[illegible]	3,327,800	4.9	1,703,500	4.5	1,766,400	5.4	2,679	543	540
Atlanta, GA	[illegible]	2,621,100	8.4	412,200	4.6	2,427,800	9.0	3,132	132	132
1,000,000 - 2,499,999 . .	[illegible]	5,786,600	4.4	[illegible]	2.8	3,848,200	5.4	4,002	688	685
500,000 - 999,999	[illegible]	10,572,300	5.0	[illegible]	4.7	5,461,900	5.3	12,721	3,559	3,515
300,000 - 499,999	[illegible]	6,673,700	4.0	[illegible]	3.7	4,022,500	4.2	10,403	1,571	1,511
200,000 - 299,999	[illegible]	4,436,900	3.9	[illegible]	3.4	[illegible]	4.3	8,021	1,624	1,582
100,000 - 199,999	[illegible]	5,151,100	3.8	2,841,600	5.2	2,503,100	2.2	9,050	1,685	1,561
70,000 - 99,999	[illegible]	2,464,500	2.3	[illegible]	2.8	1,185,000	1.7	6,398	928	885
50,000 - 69,999	[illegible]	1,133,600	2.4	694,800	2.5	465,600	2.2	2,679	601	590
Less than 50,000	[illegible]	455,000	.0	311,800	1.9	143,000	-4.1	1,195	262	241
Total in RMAs	[illegible]	49,686,800	4.6	22,383,400	4.1	29,573,200	4.9	64,193	12,283	11,952
Not in RMAs	[illegible]	27,912,100	2.8					772,875		
TOTAL, SOUTH	80,636,700	77,597,900	3.9					837,068		

West

Los Angeles, CA	12,264,800	11,705,000	4.7	3,620,000	3.9	8,634,800	5.1	2,595	469	469
San Francisco-Oakland-San Jose, CA	[illegible]	5,390,900	4.0	[illegible]	2.5	3,680,100	4.8	2,047	275	274
Seattle-Tacoma, WA . . .	[illegible]	[illegible]	5.1	[illegible]	4.4	1,973,400	5.4	2,947	132	132
1,000,000 - 2,499,999 . .	[illegible]	9,565,200	7.3	[illegible]	6.8	[illegible]	7.6	[illegible]	1,256	1,251
500,000 - 999,999	[illegible]	[illegible]	7.8	[illegible]	7.9	2,270,600	7.8	2,931	669	662
300,000 - 499,999	[illegible]	1,387,700	7.4	[illegible]	7.3	[illegible]	7.4	1,173	383	376
200,000 - 299,999	[illegible]	2,751,200	6.6	[illegible]	6.7	1,141,700	6.3	4,279	2,161	2,159
100,000 - 199,999	[illegible]	2,721,900	8.6	[illegible]	7.6	1,276,600	5.1	3,564	731	697
70,000 - 99,999	[illegible]	1,028,100	6.3	[illegible]	6.3	432,300	6.3	1,597	263	249
50,000 - 69,999	[illegible]	864,000	5.2	[illegible]	5.0	274,400	5.5	1,218	336	337
Less than 50,000	161,800	172,700	5.3	136,600	4.7	45,200	7.1	861	771	771
Total in RMAs	[illegible]	42,205,300	5.9	15,143,100	5.6	26,554,100	6.0	28,831	7,448	7,377
Not in RMAs	[illegible]	10,580,700	6.4					1,722,629		
TOTAL, WEST	[illegible]	52,786,000	6.0					1,751,460		

United States

10,000,000 & Over	[illegible]	29,015,800	2.5	11,278,100	1.8	18,452,500	2.9	8,881	802	802
5,000,000 - 9,999,999 . .	[illegible]	18,608,100	2.6	[illegible]	.9	12,622,400	3.5	9,104	656	655
2,500,000 - 4,999,999 . .	[illegible]	24,097,900	3.9	[illegible]	3.0	[illegible]	4.3	18,757	1,794	1,781
1,000,000 - 2,499,999 . .	[illegible]	36,362,200	4.0	[illegible]	3.0	25,576,800	4.5	32,033	3,440	3,429
500,000 - 999,999	[illegible]	23,596,100	4.0	[illegible]	4.0	13,467,800	4.0	[illegible]	4,916	4,861
300,000 - 499,999	[illegible]	12,403,300	3.5	[illegible]	3.7	7,269,500	3.3	18,753	2,461	2,388
200,000 - 299,999	[illegible]	12,296,800	3.6	[illegible]	4.0	6,616,600	3.3	22,362	4,592	[illegible]
100,000 - 199,999	[illegible]	13,307,300	3.7	7,343,700	4.5	6,460,900	2.7	24,456	3,914	3,466
70,000 - 99,999	[illegible]	7,471,100	2.8	[illegible]	3.2	3,719,700	2.5	18,300	2,106	[illegible]
50,000 - 69,999	[illegible]	4,463,600	2.1	[illegible]	2.8	2,078,400	1.6	[illegible]	1,512	1,486
Less than 50,000	[illegible]	1,564,900	1.3	1,058,000	2.4	527,600	-.7	4,345	1,373	1,351
Total in RMAs	189,416,800	183,184,800	3.4	74,537,300	3.0	114,879,300	3.6	196,699	27,266	26,806
Not in RMAs	67,348,000	65,525,300	2.8					3,342,642		
TOTAL, UNITED STATES	256,765,600	248,710,100	3.2					3,539,341		